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Strategic signaling or emotional sanctioning? An experimental study of ex post communication in a repeated public goods game*

Adam Zylbersztejn†

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†Paris School of Economics and University Paris 1 Panthéon–Sorbonne. Centre d'Economie de la Sorbonne, 106 Bd. de l'Hopital, 75013 Paris, France. adam.zylbersztejn@malix.univ-paris1.fr.

Abstract

Several experimental studies show that *ex post* communication promotes generosity in situations where individual incentives contradict with common interest, like the provision of public goods. The root underlying the effect of this institution, especially in a repeated interaction, is nonetheless still obscure. This study provides a novel empirical testbed for two mechanisms by which *ex post* communication may affect behavior in repeated interactions: one is related to strategic signaling, the other involves emotions induces by others' opinions.
The main findings are as follows. First, the presence of *ex post* communication (conducted through the attribution of costless disapproval points) fosters pro-social behavior and reduces free-riding. Second, I find systematic evidence that subjects tend to use *ex post* communication as a signaling device, whilst no evidence in favor of the emotion-based hypothesis.
A possible interpretation of this phenomenon is that *ex post* messages are used to announce future sanctions for free-riding.

Keywords: Public goods game, Voluntary Contribution Mechanism, Ex post communication.

JEL Classification: C72, D83.

Abstract

Les études expérimentales montrent que la communication a posteriori promeut la générosité dans les dilemmes sociaux où les incitations individuelles sont en contradiction avec l'intérêt commun, comme la contribution aux biens publics. Néanmoins, la nature de cette institution, notamment dans une interaction répétée, reste largement inexpliquée. Mon étude propose un test empirique de deux mécanismes par lesquels la communication a posteriori peut influencer sur le comportement dans les interactions répétées: l'un est lié à la signalisation stratégique, l'autre implique des émotions induit par l'opinion des autres.
La présence de la communication a posteriori (menée par l'attribution de points de désapprobation gratuits) renforce le comportement pro-social et réduit le free-riding. Je trouve des preuves systématiques que la communication a posteriori constitue un moyen de signalisation, et aucune preuve en faveur de l'hypothèse basée sur l'émotion. Une interprétation possible de ce phénomène est que les messages sont utilisés pour annoncer des sanctions pour les passages clandestins.

Mots-clefs: Biens publics, Communication a posteriori.

1 Introduction

A growing body of experimental studies find that institutions promote pro-social norms of behavior in economic contexts where individual rationality conflicts with social interest. These institutions are predominantly based on two mechanisms: pre-play communication and monetary punishment.[1] This paper is devoted to an institution that has been only recently brought to economists' attention as a means of inducing efficiency in social dilemmas: *ex post* communication. Existing empirical results are so far sparse, but encouraging. The root underlying the effect of this institution, especially in a repeated interaction, is nonetheless still obscure. Hence, the contribution of this study is twofold. First, it provides a novel empirical testbed for two mechanisms by which *ex post* communication may potentially affect behavior in a repeated interaction: one is related to signaling, the other points to the impact of emotions induces by others' opinion on individual decisions. Second, it reports new evidence on the role of this institution in overcoming selfishness in social dilemmas.

In a seminal contribution, Masclet, Noussair, Tucker, and Villeval (2003) use a repeated four-person public goods game, based on the voluntary contribution mechanism (VCM in short). After each round, every subject observes his group members' contributions, sends a message containing *disapproval points* to each group member, and is informed about the sum of points received from others. Masclet et al. conjecture that *ex post* communication in a repeated interaction may affect subjects' behavior in two ways. First, it may serve as an information transmission device prior to the next round – for instance, signal may convey a warning that the sender will decrease his future contribution unless the receiver increases his. Second, being aware of others' opinions may affect emotions – for instance, people may display an aversion to being disapproved/a preference for being approved, and try to act so as to avoid/deserve it.[2] They argue that these two effects may be separated by confronting subjects' behavior under partner and stranger matching. Intuitively, in the latter the effect of *ex post* communication may stem from both strategic information transmission and disapproval-aversion, while in the former behavioral effects may only be a matter of subjects' aversion to disapproval. In their experiment, partner matching yields significantly higher contributions than stranger matching, which supports the information transmission hypothesis. In a related study, Peeters and Vorsatz (forthcoming) use a similar experimental game and introduce treatments in which every subject may transmit an emoticon (frownies in one conditions, smilies in the other) to each parter, and then is informed about the number of emoticons he received. Confronting patterns of behavior under partner (where a moderate treatment effect is observed) and

[1] See Masclet, Noussair, and Villeval (forthcoming) for a review of this literature.

[2] Masclet, Noussair, Tucker, and Villeval (2003) refer to *ex post* communication as *non-monetary sanctioning*, provided that in a companion treatment attributed points are transformed into monetary punishment. Similar nomenclature (like *informal sanctions* or *non-monetary punishment*) is also used in other papers discussed in this section. Since my goal is to test whether this institution is actually used to inform or to sanction people, I consistently use a more neutral term – *ex post* communication.

stranger matching (where there is virtually no effect), the paper concludes that *ex post* messages is unlikely to involve emotions, but rather facilitates the exchange of information before upcoming round.[3]

However, methodology based on a direct comparison of outcomes arising under partner and stranger matching may be misleading. An extensive survey by Andreoni and Croson (2008) not only reveals that both matching schemes (partner and stranger) are very likely to affect *per se* subjects' behavior in repeated public goods games, but also that the relationship between both protocols is ambiguous – in some experiments partner matching provides higher contributions, other studies report the opposite. Consequently, comparing outcomes observed under stranger and partner matching dissembles the issue of disentangling proper treatment effects from simultaneous variation in behavior due to matching method.[4]

Herein, I propose a novel test of hypotheses put forward by Masclet, Noussair, Tucker, and Villeval (2003). The design of my experiment builds on Masclet et al.'s sound intuition that under both partner and stranger matching *ex post* communication may affect subjects' emotions, but only the former also allows for strategic signaling. At the same time, the experiment neutralizes unwanted effects of matching protocol on contributions. The main findings are as follows. First, the presence of *ex post* communication fosters pro-social behavior and reduces free-riding. Second, I find systematic evidence that subjects tend to use *ex post* communication as a signaling device, while no evidence in favor of the emotion-based hypothesis.

[3]Some studies, on the other hand, suggest that the effect of *ex post* communication in social dilemmas is driven by emotions. For instance, López-Pérez and Vorsatz (2010) report that the availability of fixed-form, post-play messages makes subjects more cooperative in a one-shot prisoner's dilemma game. Study by Czap, Czap, Khachaturyan, Burbach, and Lynne (2011) implements a two-stage game in which a common-pool resource is used by a group of subjects, out of which some have private incentives to produce publicly undesirable externalities. They find that the reception of a negative emotional feedback (via frownies) after the first stage reduces externalities in the second stage, while providing positive feedback (via smilies) is detrimental with this respect. See also Xiao and Houser (2009), Ellingsen and Johannesson (2008) and Dugar (2010) for related evidence.

[4]Masclet, Noussair, Tucker, and Villeval (2003) provide a way to control for matching protocol effects by combining within- and between-subject approach: in every session subjects play a sequence of rounds without communication, which is followed by an analogous sequence with communication, and then another sequence without communication, holding matching protocol constant. They argue that since subjects' behavior is similar in the initial sequence under both matching schemes, thus the differences observed in the second stage are unlikely to stem from matching protocol effects. Peeters and Vorsatz (forthcoming) use a classical between-subject design and observe an important scope of matching protocol effects: in each round of every treatment, partner matching induces higher contributions than stranger matching (see the working paper version of their study, Peeters and Vorsatz (2009)). In any case, it seems that the safest way to deal with these unpredictable effects is to prevent them from happening in the first place.

2 Empirical strategy

The experimental methodology introduced by Masclet, Noussair, Tucker, and Villeval (2003) and subsequently used by Peeters and Vorsatz (forthcoming) has one important virtue and one important inconvenience when it comes to disentangling the signaling dimension and the emotional dimension of *ex post* communication in a repeated interaction. Its advantage is that it identifies environments where both of these phenomena either can or cannot coexist. The main disadvantage is that these environments may *per se* affect behavior simultaneously to the content of messages, and this effect is furthermore unpredictable and virtually unmeasurable. Thus, the main challenge underlying my empirical strategy is to maintain the former feature, while dealing with the latter.

To this end, I introduce an innovative uniform matching protocol. In each round of a repeated game, subjects decide upon their level on contribution before learning whether their group prevails until next round. Consequently, I neutralize the forward-looking strategic effects of matching protocol on contributions, while controlling for the backward-looking factors (as discussed in the next section). *Ex post* communication, in turn, only takes place after the fate of groups is known to subjects. Consequently, the effect of communication can be captured in two different strategic contexts: when groups prevail from one period to another, and when they change between rounds. In line with the Masclet et al. original argument, strategic information transmission is solely possible in the latter case, while referring to emotions may occur in both cases.

Like Masclet, Noussair, Tucker, and Villeval (2003) and Peeters and Vorsatz (forthcoming), I implement non-verbal communication. In order to assure the interpretability of messages, my experimental setting includes the following characteristics. First, the VCM game is played by groups of two subjects, so in each round every participant learns about other group member's contribution, sends a message and receives one in return. Consequently, messages may be easily matched to actions, which creates an environment that *(i)* facilitates agents' comprehension of non-verbal content, and *(ii)* allows the experimenter to establish a relationship between individual messages and individual contributions.[5] Second, it is of common knowledge that no group ever re-appears after having been re-matched, which rules out strategic information transmission between subjects who are about to cease interacting.[6]

[5]It should me mentioned that studies by Masclet, Noussair, Tucker, and Villeval (2003) and Peeters and Vorsatz (forthcoming) (that use a four-person VCM game) explore the formation and the role of monetary and non-monetary mechanisms of peer pressure, which differs substantially from my objective. In these experiments, players evaluate remaining group members' actions, and receive a bundled message containing the sum of three evaluations attributed to him by others (via either points or emoticons), which makes the link between a single message and a single action is much more ambiguous.

[6]In contrast, the stranger matching procedures adopted by Masclet, Noussair, Tucker, and Villeval (2003) and Peeters and Vorsatz (forthcoming) are not "leakproof": the same subjects may interact multiple times throughout the experiment, even though they can never ascertain each other's identity. Masclet, Noussair, Tucker, and Villeval (2003) inform subjects that the probability of being matched with anyone for two consecutive rounds is null, and that the same applies to being part of the same group of four players more than once throughout the experiment. Peeters

2.1 Experimental game and conditions

Experimental game. Pairs of subjects play the following version of VCM game. Each player holds an initial endowment of 15 Experimental Currency Units (ECU), and may contribute any part of it to the common pool.[7] Decisions are made simultaneously and the amount accumulated in the common pool is then multiplied by 1.5 and re-transferred to group members in equal parts. Thus, the gain of player i who contributes N_i and interacts with player j who contributes M_j equals:

$$Gain_i = 15 - 0.25 \times N_i + 0.75 \times M_j \tag{1}$$

Although social welfare is maximized when each player contributes his entire endowment, the dominant strategy is to contribute nothing.[8]

Baseline condition. In the baseline condition (BC for short), the game is repeated in the following way. In each occurrence, subjects *(i)* decide upon their contribution to the common pool, *(ii)* learn whether their current group prevails until next round, and finally *(iii)* observe other group member's contribution, as well as personal gain. Subjects are informed that groups survive with a 50% chance, and that every change is permanent – groups that disappear cannot re-appear in the future. In all rounds following round 1, an announcement prior to stage *(i)* reminds subjects whether their group has changed with respect to the previous period. The important issue of the asymmetry of information about players' past behavior between maintained and newly formed groups is addressed in the following way. Before stage *(i)*, members of newly matched pairs are informed about the decision that was taken recently by their current group member in his former group.

Evaluation condition. Evaluation condition (EC in short) encompasses the three stages forming BC, as well as the current-group-status reminder. In addition, in stage *(iv)* subjects are asked to express their opinion about group member's decision by attributing him a certain number of points (between 0 and 10). Experimental instructions state that *a high number of points expresses disapproval: 10 points correspond to the strongest disapproval, while 0 points correspond to the weakest disapproval,* and that *attributed points do not affect either participant's gains for the experiment.*[9] Then, each subject is informed about the number of points he received from the other group member. If groups change between periods $t-1$ and t, prior to stage *(i)* subjects not only learn about the decision taken by their current group member in $t-1$ (like in BC), but also

and Vorsatz (forthcoming) allow for a completely random matching. Clearly, this makes strategic information transmission between subjects across rounds much more difficult, but not impossible.

[7]In the lab implementation, contributions may only take integer values between 0 ECU and 15 ECU.

[8]To avoid framing effects, instructions use neutral phrasing: I use expressions such as *players* and *group members* rather than *partner*, and *contributions* are never related to *cooperation*. See Rege and Telle (2004) for evidence on the effect of problem framing in public goods experiments.

[9]This closely resembles the procedure adopted by Masclet, Noussair, Tucker, and Villeval (2003).

about the number of points he received.

2.2 Experimental procedures.

The experiment involves a total o 12 sessions (6 for each experimental condition), each comprising 8 subjects. I use round-robin matching protocol (that assures that each two subjects have an opportunity to interact during the experiment) and a random group survival rule outlined above. Consequently, the structure of group matching and the number of rounds differ between sessions. In order to control for the effects of these variations, I use six independent, randomly generated matching sequences (henceforth labeled *Game 1*, ..., *Game 6*) and run two separate sessions for each of them: one implementing BC and one implementing EC. Subjects are informed that the game contains between 10 and 16 rounds and that its length is determined randomly. In practice, sessions contain between 11 and 15 rounds, and pairs of subjects interact for up to five consecutive rounds.

At the beginning of each session, participants are randomly assigned to their computers and asked to fill in a small personal questionnaire containing basic questions about their age, gender, education, *etc.* The written instructions are then read aloud. Before starting, subjects are also asked to fill in a quiz assessing their understanding of the game they are about to play. Once the quiz and all remaining questions are answered, the experiment begins.

Once all pairs complete a round of the game, subjects are either informed that a new round starts, or that the experiment ends. In the latter case, a single round is randomly drawn and each participant receives the amount in EUR corresponding to his gains in that round (converted from ECU to EUR using an exchange rate 1 ECU = 0.40 EUR), plus a show-up fee equal to 5 EUR.

All sessions took place in the lab of University Paris 1 (LEEP) in July 2012. The recruitment of subjects has been carried out via LEEP database among individuals who have successfully completed the registration process on Laboratory's website.[10] Among 96 participants, 51 are males and 45 are females. 63 participant are students, among which 67% might have some background in game theory due to their field of study.[11] 82 subjects took part in experiments organized in LEEP in the past. Participants' average age is roughly 25. No subject participated in more than one experimental session. Each session lasted about 45 minutes, with an average payoff of 12.20 Euros.

Table 1: Average contributions according to treatment and experimental game

Conditions	Game 1	Game 2	Game 3	Game 4	Game 5	Game 6	Average	p
Average contributions in round 1								
Baseline	7.625	6.750	8.125	6.375	5.750	3.875	6.417	0.210
Evaluation	6.250	8.250	6.500	8.375	7.875	8.750	7.667	
Overall average contributions								
Baseline	5.000	2.900	4.420	3.083	6.010	2.846	3.942	0.046
Evaluation	4.083	7.783	6.045	6.325	9.135	8.029	6.938	
Session details								
Number of subjects	8	8	8	8	8	8		
Number of rounds	12	15	11	15	12	13		

Note. Columns 1-6 present average contributions in each experimental game, using data from round 1 (upper part) and all rounds (middle part). The last two columns summarize these results and provide non-parametric tests for the significance of the effect of treatment on contributions: the Wilcoxon-Mann-Whitney rank-sum test using individual observations in round 1, and Wilcoxon signed-rank test using game-level matched averages for the aggregate data. The lower part of the table contains additional information on the number of subjects and the length of each experimental game.

3 Results

This section establishes four principal results arising from aggregate and individual data analysis. In aggregate terms, I report that the presence of *ex post* communication restrains selfishness. Individual data suggest that the cause of this behavioral transition lies in strategic signaling rather than emotional pressure.

4 Aggregate treatment effects

Table 1 presents subjects' average contributions as a function of the structure of experimental game and experimental condition. The principal finding is the following:

Result 1. Average contribution in evaluation condition significantly increases as compared to baseline condition. However, this effect does not occur in the initial round.

Support 1. In five experimental games out of six, the presence of *ex post* communication increases the average contribution. This shift of behavior is significant at the 5% level according to the Wilcoxon signed-rank test.[12] On the other hand, a Wilcoxon-Mann-Whitney rank-sum test using individual observations from round 1 does not reject the hypothesis that subjects' behavior is the

[10]The recruitment uses ORSEE Greiner (2004); the experiment is computerized through a software developed under REGATE Zeiliger (2000).

[11]Disciplines such as economics, engineering, management, political science, psychology, mathematics applied in social science, mathematics, computer science, sociology, biology.

[12]For each of the six games, this test matches averge contributions observed in BC and in EC, and therefore accounts for the effects related to different game structures.

Table 2: Aggregate determinants of contributions

	α	p	α	p
Determinants:	Round 1		Overall	
Intercept (α_0)	5.429	0.000	0.313	0.944
$\mathbf{1}[Evaluation\_condition]$ (α_1)	1.413	0.186	4.770	0.045
Game_2 (α_2)	1.530	0.411	0.843	0.858
Game_3 (α_3)	0.723	0.698	1.838	0.706
Game_4 (α_4)	0.877	0.636	0.884	0.838
Game_5 (α_5)	0.634	0.732	5.288	0.317
Game_6 (α_6)	-0.252	0.892	1.490	0.730

Note. Tobit regressions of subject's contribution on the set of explanatory variables including dummies indicating treatment and experimental games. The round 1 regression uses 8 independent observations from each session (96 in total). The overall regression uses 1248 observations from 12 experimental sessions, standard errors are estimated using observations clustered at the session level, and then corrected using delete-one jackknife.

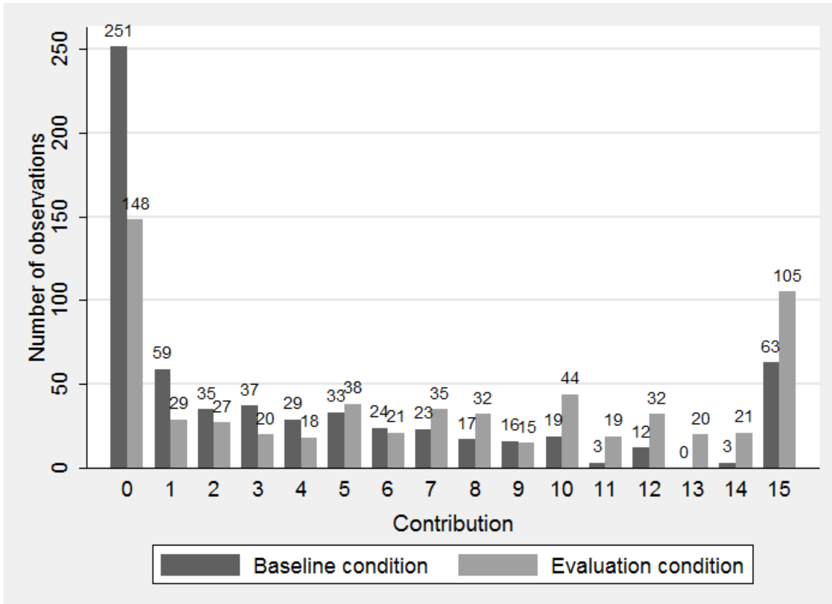
same in both experimental environments (p=0.210). ■

Support 2. The effect of treatment variable is quantified using regression models summarized in Table 2. Controlling for game-structure fixed effects (dummies $Game\_2, \ldots, Game\_6$), I find that the overall impact of communication (dummy $\mathbf{1}[Evaluation\_condition]$ equal to 1 for EC, 0 for BC) on subjects' contributions is highly positive and significant at the 5% level ($H_0 : \alpha_1 = 0$, $p = 0.045$).[13] On the other hand, regression analysis points to the insignificance of treatment variable in round 1 ($H_0 : \alpha_1 = 0$, $p = 0.186$). ■

To further highlight the behavioral transition caused by the presence of communication, Figure 4 compares distributions of contributed amounts in both experimental conditions. In BC, over 40% (251 out of 624) of decisions result in a null contribution, as compared to less than 25% (148/624) in EC. Moreover, contributions between 1 ECU and 4 ECU are more frequent in the former than in the latter. Then, the relationship between the two conditions is unstable until the threshold level of 10 ECU, above which all values appear substantially more often in EC than in BC, including the case in which the entire endowment is tranferred to the common pool (105 times in EC against 63 times in BT).

[13] Since subjects' contributions often take extreme values (either 0 or 15), all models explaining changes in this variable rely on a double-censored tobit regression rather than a simple OLS regression. By the same token, all models explaining the pattern of the attribution of evaluation points (ranging between 0 and 10) are also double-censored tobit. Furthermore, in order to account for the within-session correlation between individual observations *after* the initial round of the game, standard errors are calculated for data clustered at the session level, and corrected for the potential small-sample bias using the leave-one-out jackknife procedure; see Bell and McCaffrey (2002), Cameron, Gelbach, and Miller (2008), Jacquemet and Zylbersztejn (2010) for a related discussion. Observations from round 1 are considered independent. All reported p-values come from two-sided tests.

Figure 1: Distribution of contributions across treatments



Note. For each experimental treatment, data contain 624 observations from 6 experimental sessions. Contributions are given in ECU.

5 Individual behavior

This section explores the determinants of individual decisions in both experimental conditions. In particular, it highlights the patterns by which information coming from two different sources – *ex post* communication and observation of other players' history – affects individual choices. Like previous studies by Masclet, Noussair, Tucker, and Villeval (2003) and Peeters and Vorsatz (forthcoming), I categorize observations according to the relative importance of contribution to the group. The term *excessive contributor* describes a subject who contributes more then the other group member, otherwise subject is referred to as *moderate contributor*.

5.1 Impact of information on contributions

Results provided in this section relies on a linear model relating the level of contribution in t to current $Round$ and a set of events from $t-1$: $Own\_contribution_{t-1}$ and $Group\_member's\_contribution_{t-1}$, (in the evaluation treatment only) the number of points he has sent to ($Sent\_points_{t-1}$) and received from the other player ($Received\_points_{t-1}$). The effects linked to group re-matching are captured by the following variables: $\mathbf{1}[Re-matching_{t-1}]$ (dummy equal to if groups are re-matched between periods $t-1$ and t, 0 otherwise), its interactions with variables mentioned above,

Table 3: Individual determinants of contributions

Status in $t-1$	Excessive contributor				Moderate contributor			
Experimental condition	Baseline		Evaluation		Baseline		Evaluation	
Determinants:	β	p	β	p	β	p	β	p
$Intercept$ (β_0)	-3.801	0.196	3.818	0.244	-2.082	0.254	-2.814	0.485
$Own\_contribution_{t-1}$ (β_1)	0.864	0.107	0.413	0.087	1.260	0.022	1.442	0.002
$Group\_member's\_contribution_{t-1}$ (β_2)	0.813	0.072	0.542	0.039	0.109	0.211	0.099	0.727
$Received\_points_{t-1}$ (β_3)	—	—	-0.258	0.489	—	—	0.447	0.029
$Sent\_points_{t-1}$ (β_4)	—	—	-0.437	0.013	—	—	0.020	0.920
$Round$ (β_5)	-0.171	0.490	-0.012	0.925	-0.162	0.325	-0.126	0.551
$\mathbf{1}[Re-matching_{t-1}]$ (β_6)	3.038	0.104	-5.495	0.209	4.094	0.235	4.196	0.270
$\times Own\_contribution_{t-1}$ (β_7)	-0.358	0.243	0.365	0.061	-0.625	0.429	-0.807	0.033
$\times Partner's\_contribution_{t-1}$ (β_8)	-0.926	0.005	-0.505	0.169	-0.183	0.236	-0.218	0.492
$\times Received\_points_{t-1}$ (β_9)	—	—	0.666	0.248	—	—	-0.677	0.001
$\times Sent\_points_{t-1}$ (β_{10})	—	—	0.264	0.061	—	—	-0.056	0.902
$\times New\_GM's\_received\_points_{t-1}$ (β_{11})	—	—	0.191	0.591	—	—	0.051	0.837
$\times New\_GM's\_contribution_{t-1}$ (β_{12})	0.288	0.024	0.491	0.008	0.047	0.743	0.260	0.147
$\times Round$ (β_{13})	0.122	0.611	-0.142	0.625	-0.052	0.821	0.211	0.293
Number of obs.	225		235		351		341	

Note. Tobit regressions of excessive contributors' (whose $Own\_contribution_{t-1} > Group\_member's\_contribution_{t-1}$) and moderate contributors' (whose $Own\_contribution_{t-1} \leq Group\_member's\_contribution_{t-1}$) contributions in period t on the set of variables indicating current $Round$ and events from $t-1$ including: subjects' $Own\_contribution_{t-1}$, his $Group\_member's\_contribution_{t-1}$, (in EC only) the number of points he has sent to and received from the other player, the occurrence of group re-matching (dummy $\mathbf{1}[Re-matching_{t-1}]$ equal to if groups are re-matched between periods $t-1$ and t, 0 otherwise), the interactions of $\mathbf{1}[Re-matching_{t-1}]$ with previous variables, and the information about current group member's situation in $t-1$ should re-matching occur: $New\_GM's\_received\_points_{t-1}$ and $New\_GM's\_contribution_{t-1}$. For each experimental condition, I use data from 6 sessions. Standard errors are estimated using observations clustered at the session level, and then corrected using delete-one jackknife.

and the information about current group member's situation in $t-1$ that becomes available if re-matching occurred between $t-1$ and t: $New\_GM's\_received\_points_{t-1}$ (in EC only) and $New\_GM's\_contribution_{t-1}$ (in both BC and EC). Table 3 contains the estimates of this model for four different subsets of observations, categorized according to subjects' status in $t-1$ (excessive contributor or moderate contributor) and experimental condition (baseline or evaluation).

Models suggest that in both experimental conditions excessive contributors relate their decisions to their group members' reputation, whereas moderate contributors ignore this information. Furthermore, *ex post* messages in EC systematically influence the future choices of each contributor type as long as pairs last, and have no effect after re-matching. These phenomena are described in details by the two results:

Result 2. In both experimental conditions, the contribution in t of a subject who acted as an excessive contributor in $t-1$ is increased by his current group member's contribution in $t-1$. The information about others' past behavior is ignored by subjects who acted as moderate contributors in $t-1$.

Support. Irrespective of the occurrence of re-matching between $t-1$ and t, excessive contributors' choices remain cooperative and become adapted to their current group member's reputation from $t-1$. In the absence of re-matching between $t-1$ and t, excessive contributors increase their contributions in t more the higher was other player's contribution in $t-1$ ($H_0 : \beta_2 = 0$, $p = 0.072$ in BC, $p = 0.039$ in EC). In the case of re-matching between $t-1$ and t, this information becomes irrelevant ($H_0 : \beta_2 + \beta_8 = 0$, $p = 0.738$ in BC, $p = 0.844$ in EC), instead excessive contributors adapt their contributions in accordance with their new group member's behavior in $t-1$ ($H_0 : \beta_{12} = 0$, $p = 0.024$ in BC, $p = 0.008$ in EC). Moderate contributors, in turn, ignore other players' reputation.[14] ■

Result 3. In evaluation condition, moderate contributors increase their contribution in t more the more points they received in $t-1$, and excessive contributors decrease their contributions in t more the more points they sent in $t-1$, but only if their groups prevail between $t-1$ and t.

Support. In the absence of re-matching, excessive contributors ignore evaluation received in $t-1$ ($H_0 : \beta_3 = 0$, $p = 0.489$), but at the same time their contribution decreases more the more points they sent to their group members ($H_0 : \beta_4 = 0$, $p = 0.039$). Moderate contributors, in turn, display a converse motivation, increasing their contribution in t more the more points they received in $t-1$ ($H_0 : \beta_3$, $p = 0.029$), while ignoring the points they have sent themselves ($H_0 : \beta_4 = 0$, $p = 0.920$). In the presence of re-matching between $t-1$ and t, neither sent or received points have a significant effect on excessive contributors' behavior (testing $H_0 : \beta_9 = 0$, $H_0 : \beta_{10} = 0$ yields $p = 0.226$ and $p = 0.130$, respectively). Moderate contributors remain neutral to the latter ($H_0 : \beta_3 + \beta_9 = 0$, $p = 0.897$), while their reaction to the former inverts – their contribution in t *decreases* in the number of points they received prior to re-matching ($H_0 : \beta_4 + \beta_{10} = 0$, $p = 0.018$). Lastly, the information about the number of points received by the member of current group in his former group in period $t-1$ does not affect players' decisions ($H_0 : \beta_{11} = 0$, $p = 0.591$ for excessive contributors, $p = 0.837$ for moderate contributors). ■

5.2 Formation of ex post messages

This section analyses the signal formation in evaluation treatment by establishing a link between *ex post* messages and both group members' choices. To this end, I estimate linear models representing the number of points received by a player in round t as a function of his $Own\_contribution_t$, as well as its relative size within his group – *i.e.* the magnitude of a $Positive\_deviation_t$ or a $Negative\_deviation_t$ (in absolute terms) with respect to other group member's decision. The temporal dimension is represented by variable *Round*. In order to highlight the effect of the perspective of future interaction, I furthermore divide observations according to groups' fate (survival

[14] Testing $H_0 : \beta_2 = 0$, $H_0 : \beta_2 + \beta_8 = 0$, $H_0 : \beta_{12} = 0$ yields $p = 0.211$, $p = 0.597$, $p = 0.743$ in BC, and $p = 0.727$, $p = 0.441$, and $p = 0.147$ in EC, respectively.

Table 4: Disapproval points and relative contribution

Status of group	Prevails until $t+1$		Disappears after t	
Determinants:	γ	p	γ	p
Intercept (γ_0)	6.270	0.003	5.634	0.045
$Own\_contribution_t$ (γ_1)	-0.748	0.003	-0.675	0.005
$Positive\_deviation_t$ (γ_2)	0.131	0.456	-0.135	0.207
$Negative\_deviation_t$ (γ_3)	0.351	0.012	0.326	0.132
Round (γ_4)	0.216	0.174	0.167	0.276
Number of obs.	288		288	

Note. Tobit regressions of the number of received points received in t on variables indicating the level of $Own\_contribution_t$, the value of a $Positive\_deviation_t$ or a $Negative\_deviation_t$ (in absolute terms) as compared to other player's contribution, and current *Round*. The left-hand (right-hand) side regressions use observations for which pairs prevail (change) between periods t and $t+1$. Standard errors are estimated using observations clustered at the session level, and then corrected using delete-one jackknife.

or disappearance) at the time of point attribution, and run separate regressions for each scenario. Estimates are summarized in Table 4. The main result is:

Result 4. In the evaluation treatment, moderate contributors receive significantly more points the lower is their relative contribution, but only if their group prevails until the next round.

Support. Regardless of whether groups survive or not after period t, own contribution has a similar and negative effect on the received number of points ($H_0 : \gamma_1 = 0$, $p = 0.005$ if groups change, $p = 0.003$ if they prevail). Moreover, in both cases received points are not significantly affected by the magnitude of positive deviation ($H_0 : \gamma_2 = 0$, $p = 0.207$ and $p = 0.456$, respectively). The crucial difference arises for a negative deviation: even though estimated values of γ_3 are alike in both regressions, it turns out that this effect is only significant if groups will prevail until next round ($H_0 : \gamma_3 = 0$, $p = 0.132$ and $p = 0.012$, respectively). ■

5.3 Discussion

The analysis of aggregate data provided in Section 4 shows that the availability of *ex post* communication using costless evaluation points promotes pro-social generosity in a public goods game, a result that is in line with what has been reported by Masclet, Noussair, Tucker, and Villeval (2003).

Moreover, my findings testify against the hypothesis that the effect of *ex post* communication is emotion-based. The lack of a significant inter-treatment difference in average contributions in the initial round of the game suggests that the perspective of receiving feedback from others does not make participants' behavior more cooperative, as opposed to findings put forward by López-Pérez and Vorsatz (2010). Moreover, on the individual level I find no systematic relationship between messages and actions in groups that are bound for disappearance.

On the other hand, experimental evidence suggests that *ex post* communication is used to convey strategic signals. An interesting angle to interpret this finding come from the dynamic theory of conditional cooperation proposed by Keser and van Winden (2000), according to which subjects' readiness to cooperate depends on two factors: their experience (*reactive behavior*) and their perception of future interaction (*future-oriented behavior*). In the context of this experiment, reactive behavior only seems present among excessive contributors who keep on adapting their decisions according to current group member's recent choices. Moderate contributors remain neutral to this information. This situation is persistent in both treatments, and within both maintained and changing groups. Transmission of disapproval points seems to induce future-oriented behavior for both types of players. Excessive contributors send meaningful signals (in the sense that expressed disapproval is related to the magnitude of others' free-riding) only in pairs that are known to last for at least one more period. Furthermore, these signals have a clear and consistent effect on subjects' behavior: the stronger the disapproval, the greater the reduction of future contributions from excessive contributors who send it, and the greater increase of future contributions from moderate contributors who receive it.

Therefore, the dynamic theory of conditional coordination suggests that the positive effect of *ex post* communication in this experiment stems from engaging subjects into a future-oriented cooperative behavior in pairs that survive from one period to another. One possible interpretation of this phenomenon is that these signals express penalty administered by decreasing future contribution.[15] Excessive contributors may aim at inducing group members to cooperate by making them realize the future consequences of their current misconduct. However, retaining the credibility of such warnings within randomly evolving groups also requires an immediate execution of announced sanctions. At the same time, moderate contributors may instantaneously rise their contributions in the fear of possible sanctions in the future. Obviously, such use of disapproval points leaves no sensible role for communication in pairs that are aware that their interaction is about to terminate for ever, which is clearly reflected by experimental data.

6 Conclusion

This paper provides a novel study of the role of *ex post* communication in fostering socially beneficial behavior in a repeated public goods game. I experimentally test the existence of two channels through which such communication may help improve the outcomes of repeatedly occurring social dilemmas: one is related to the transmission of strategic signals between players, the other involves subjects' emotions.

I report two principal findings. First, the presence of *ex post* communication (carried out via costless points expressing disapproval) significantly enhances subjects' willingness to contribute

[15] Such possibility is also mentioned in Masclet, Noussair, Tucker, and Villeval (2003).

to the public good. Second, I find evidence against the hypothesis that *ex post* messages affect subjects' behavior through emotions related to others' approval or disapproval. On the other hand, experimental data systematically point towards the importance of strategic signaling. A possible interpretation of this phenomenon is that messages are used to announce sanctions for free-riding.

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